ELECTROMAGNETIC PROPERTIES OF THE SU(3) OCTET BARYONS IN THE SEMIBOSONIZED SU(3) NAMBU–JONA-LASINIO MODEL [1]

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Abstract

The electromagnetic properties of the SU(3) octet baryons are investigated in the semibosonized SU(3) Nambu–Jona-Lasinio model.The rotational $1/N_c$ and strange quark mass corrections in linear order are taken into account. It turns out that the model is in good agreement with the experimental data.

The baryon in the semibosonized Nambu–Jona-Lasinio model (often called chiral quark-soliton model) is regarded as N_c valence quarks coupled to the polarized Dirac sea bound by a non-trivial chiral field configuration in the Hartree approximation [1]. This picture of the baryon can be justified in the large N_c limit[2]. The model has been found to be very successful in describing the static properties of the nucleon and its form factors[3]–[5] in SU(2). The model was generalized to SU(3) by Weigel *et al.* [6] and Blotz *et al.*[7] and the mass-splittings of hyperons were in remarkable agreement with experimental data.

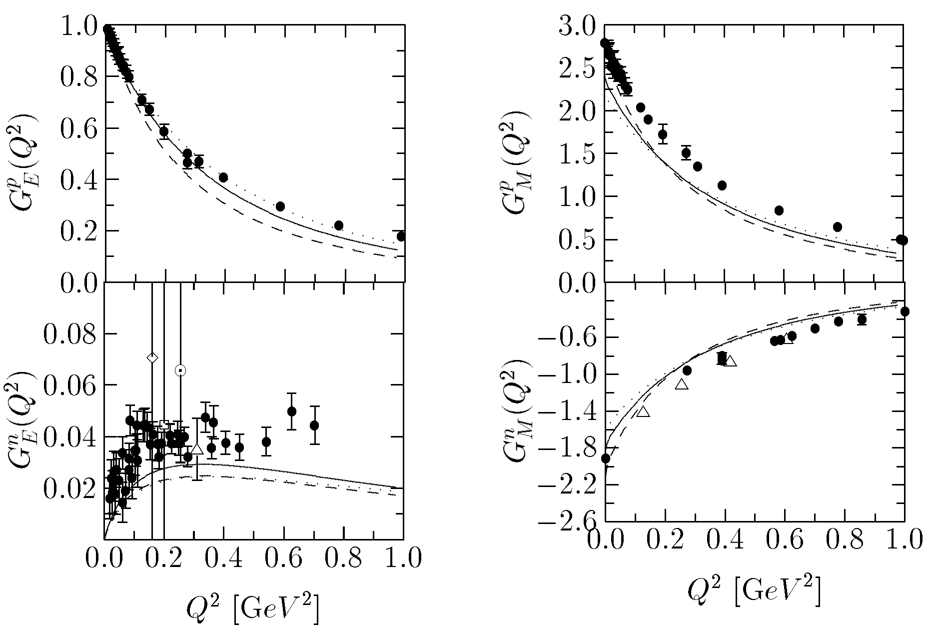

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Fig. 1:The electromagnetic form factors of the nucleon as functions of Q^2: In the left panel the electric form factors of the nucleon are drawn, whereas in the right panel its magnetic formfactors are depicted. The dashed curve corresponds to the constituent quark mass $M = 370$MeV, while solid curve is for $M = 420$MeV. The dotted curve displays the case of $M = 450$MeV. The empirical data for the electric form factor of the proton are taken from Höhler *et al.*[10], while those for the proton one are from Platchkov *et al.* [11]. The other four points in the $G_E^n(Q^2)$ are results for G_E^n extracted by Woodward *et al.*[12] (open diamond), by Thompson *et al.*[13] (open box), by Eden *et al.*[14] (open circle) and by Meyerhoff *et al.*[15] (open triangle). The empirical data for the magnetic form factors are taken from Höhler *et al.* [10] while the data with open triangles are due to the most recent experiment [16].

In this talk, we will present a recent investigation of the electromagnetic properties of the SU(3) octet baryons in this model. Their explicit calculation can be found in ref.[8, 9].

Fig. 1 shows the electromagnetic form factors of the nucleon with the constituent quark mass varied from 370 MeV to 450 MeV. We select $M = 420$ MeV for our best fit consistently with the mass splittings. It is found that the proton electric form factor is insensitive to the constituent quark mass and it agrees with the empirical data by Höhler (Höhler *et al.* 1990).

As can be seen from fig.2, the result of the neutron electric form factors in SU(3) turns out to be quite different from that in SU(2). This discrepancy can be explained by the fact that the isoscalar part of the charge operator $\hat{Q}$ in SU(3) is not invariant under the rotation on the contrary to SU(2). This causes the reduction of the electric isoscalar form factors in SU(3) and as a result the sizably smaller electric form factor of the neutron is obtained, compared to that of the SU(2) model. The nucleon magnetic form factors are displayed also in the right panel of fig.1.

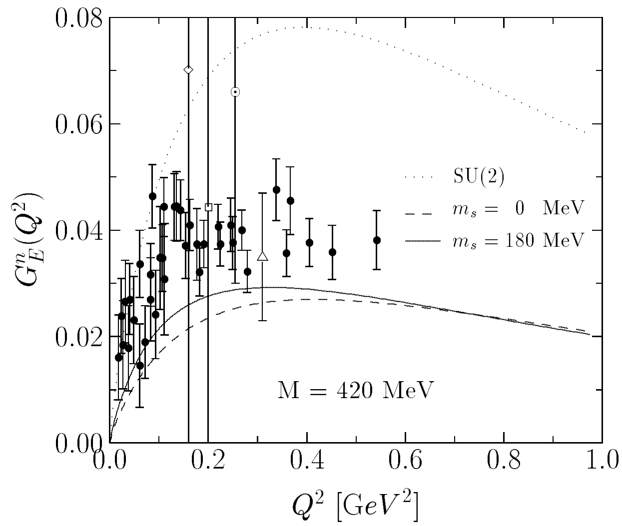

Fig. 2: The neutron electric formfactor as a function of Q^2: The solid curve corresponds to the strange quark mass $m_s = 180$ MeV, while dashed curve draws without m_s. The dotted curve displays the case of the SU(2) model. $M = 420$ MeV is chosen for the constituent quark mass. The empirical and experimental data label the same cases as in G_E^n of fig. 1.

They are also in a good agreement with experimental data.

In table 1 we list the magnetic moments and electromagnetic charge radii of the SU(3) octet baryons. Recently, Bae and McGovern [17] made a χ^2 analysis of the hyperon magnetic

moments for possible hedgehog models, according to which the present NJL model emerges as the best of hedgehog models. The results are in a good agreement with the experimental data within about 15% which is more or less the upper limit attained in any model with " *hedgehog symmetry*" [9]. We now turn our attention to the electromagnetic form factors

Table 1: The electromagnetic static properties of the SU(3) octet baryons. The constituent quark mass M is used.

Baryons	$\langle r^2\rangle_E[\mathrm{fm}^2]$	exp.	$\mu_B[n.m.]$	exp.	$\langle r^2\rangle_M[\mathrm{fm}^2]$	exp.
p	0.78	0.74	2.39	2.79	0.70	0.74
n	-0.09	-0.11	-1.76	-1.91	0.78	0.77
Λ	-0.04	–	-0.77	-0.61	0.70	–
Σ^+	0.79	–	2.42	2.46	0.71	–
Σ^0	0.02	–	0.75	–	0.70	–
Σ^-	-0.75	–	-0.92	-1.16	0.74	–
Ξ^0	-0.06	–	-1.64	-1.25	0.75	–
Ξ^-	-0.72	–	-0.68	-0.65	0.51	–

of other SU(3) hyperons. In fig. 3 we present the electric form factors for the SU(3) octet hyperons while in fig. 4 we draw the magnetic form factors of the hyperons.

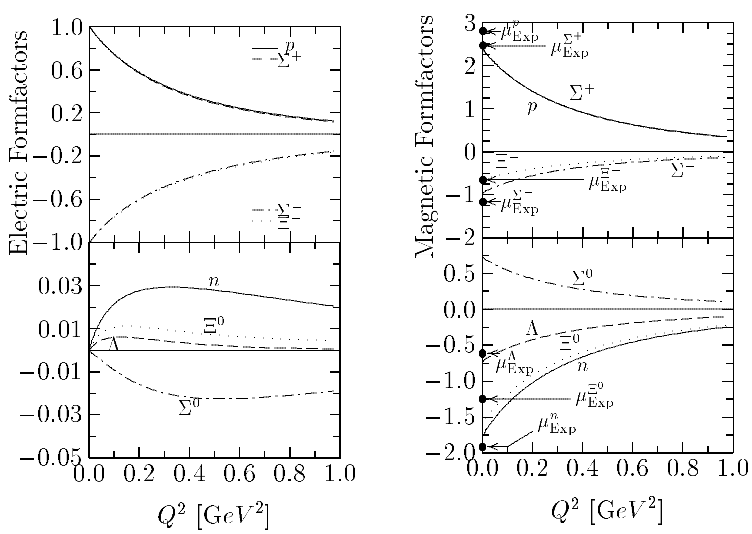

Fig. 3: The electromagnetic formfactors of SU(3) octet hyperons: In the left panel the corresponding electric form factors are drawn and in the right panel the magnetic ones are depicted.

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